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ORIGINAL RESEARCH

The Association Between Daily Step Count, Step Frequency and the Risk of Chronic Obstructive Pulmonary Disease: A Cross-Sectional Study Using NHANES Data

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Background: Chronic obstructive pulmonary disease (COPD) is a major public health concern globally, and physical activity is considered a modifiable factor in its prevention.

Purpose: This study examined the association between daily step count, step frequency, and the prevalence of chronic obstructive pulmonary disease (COPD) using nationally representative data.

Patients and Methods: A cross-sectional analysis was conducted using data from adults aged ≥40 years in the 2003–2006 National Health and Nutrition Examination Survey (NHANES). Participants wore accelerometers for 7 days to measure daily step count and three step frequency indicators: bout cadence, peak 30-minute cadence, and peak 1-minute cadence (steps/minute). Weighted logistic regression was used to assess associations with COPD, adjusting for demographic, behavioral, and health-related covariates. Sensitivity analyses and subgroup analyses were conducted to confirm robustness.

Results: Among 3690 participants (representing ~26.8 million US adults), higher daily step count and step frequency were inversely associated with COPD prevalence. Compared to those taking <4000 steps/day, those taking ≥8000 steps/day had a 63% lower odds of COPD (OR 0.37, 95% CI 0.15–0.91; P for trend <0.001). Higher bout cadence (92.3–153.4 steps/minute) and peak 30-minute cadence (69.8–128.2 steps/minute) were also associated with significantly reduced COPD odds (ORs 0.30 and 0.33, respectively). Combined higher step count and frequency yielded a greater risk reduction. Restricted cubic splines indicated a nonlinear association, and ROC analysis showed moderate discriminatory power (AUC 0.71–0.75). Results remained robust in sensitivity analyses and across subgroups.

Conclusion: In this cross-sectional study of US adults, higher daily step counts and greater walking cadence were associated with a lower prevalence of COPD. These findings support the relevance of step-based metrics in assessing COPD risk, although longitudinal studies are needed to establish causality.

Keywords: chronic obstructive pulmonary disease, NHANES database, physical activity, step count, step frequency

Introduction

Physical activity is essential for maintaining overall health,Studies indicate that physical activity reduces the risk of non-communicable diseases and mortality while enhancing quality of life.[1,2] Individuals with chronic obstructive pulmonary disease (COPD) typically engage in less physical activity than the general population.[3] Low physical activity levels are significantly associated with increased hospitalization risk and may contribute to higher all-cause mortality in patients with COPD.[4] Regular physical activity (PA) in patients with chronic obstructive pulmonary disease (COPD) exerts anti-inflammatory and antioxidant effects, thereby improving clinical outcomes by lowering hospitalization rates, reducing the frequency of acute exacerbations, and decreasing mortality risk.[5,6] However, pathological factors such as activity-induced

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dyspnea and diminished exercise tolerance lead many COPD patients to reduce physical activity levels, often falling short of WHO recommendations for regular exercise.[7,8] Therefore, it is clinically important to develop physical activity programs tailored to the specific pathological conditions of COPD patients to maximize clinical benefits.

Daily step count serves as a simple, effective, and quantifiable indicator of physical activity, reflecting an individual's overall activity level and offering an objective measure for daily assessment.The widespread use of smart wearable devices and big data analytics has further validated the utility of daily step count as a tool for health monitoring and management.[1,2] Existing evidence indicates a significant correlation between step count and various health indicators, especially in chronic disease management, where increased step count is often linked to improved clinical outcomes.[9] Cadence, defined as the number of steps taken over a given period (eg, steps per minute), is a key indicator of walking intensity and provides valuable insight into exercise intensity and related health benefits.[10] However, evidence on the association between step count, step cadence, and the risk of developing COPD remains limited.Further research is needed to clarify the potential role of step count and step cadence in preventing COPD, aiming to inform personalized prevention strategies.

This study uses data from the US National Health and Nutrition Examination Survey (NHANES) to examine the associations between daily step count, step intensity (cadence, measured in steps per minute), and the risk of self-reported COPD.The aim is to provide key scientific evidence to support the development of wearable device–based primary prevention strategies for COPD.The public health relevance of this research lies in its potential to establish a comprehensive prevention framework—ranging from individual behavioral interventions to community-level health promotion—by leveraging daily step count as a simple and scalable metric.This approach is particularly suitable for promoting innovation in chronic disease management, especially in resource-limited settings, and may offer effective strategies for preventing and managing COPD.

Materials and Methods

Study Population

This study utilized data from two cycles (2003–2006) of the National Health and Nutrition Examination Survey (NHANES), conducted by the Centers for Disease Control and Prevention (CDC).NHANES is a cross-sectional survey that collects health and nutritional data from a nationally representative sample of US households.The Institutional Review Board of the National Center for Health Statistics approved all NHANES protocols, and all participants provided written informed consent.Although the NHANES dataset is publicly available and contains no personally identifiable information, in accordance with the ethical requirements of the target journal, this study was reviewed and approved by the Ethics Committee of Liaocheng People's Hospital (Approval No. 2025133).All data in this study are publicly available and demographically weighted for analysis (accessible at https://www.cdc.gov/nchs/nhanes/).Participants completed a face-to-face interview and underwent physical examinations and laboratory tests at a mobile examination center. This study analyzed data from individuals aged 40 years and older from the 2003–2006 NHANES cycles.COPD diagnosis was based on an affirmative response to any of the following questions: "Do you still have chronic bronchitis?" "Have you ever been told you have emphysema?" or "Have you ever been told you have chronic bronchitis?".[11]

Exposure Ascertainment

Between 2003 and 2006, participants in the NHANES wore an ActiGraph model 7164 accelerometer (manufactured by ActiGraph, Fort Walton Beach, Florida) on their hip for seven consecutive days during waking hours as part of the Physical Activity Monitor (PAM) protocol.Although the NHANES activity count data for the 2003–2004 cycle were released, the step count data for that period were unavailable due to incompleteness.In 2016, researchers employed semi-parametric multiple imputation techniques based on physical activity counts to impute the missing step count data, as described and validated in the study by Saint-Maurice et al.[12] This method has been widely adopted for NHANES physical activity analyses.[12] Step counts were recorded in 60-second intervals during waking hours across the 7-day monitoring period.The validity of the step counts measured by the ActiGraph model 7164 accelerometer has been well established.[12,13] The device's converter filters and digitizes signals, accumulates activity within user-specified time intervals (time windows), and provides activity counts for each interval—typically expressed as counts per minute

(CPM) or counts per day (CPD).Initially, the data undergo preliminary screening for non-wear time using an algorithm developed for NHANES accelerometer data.Days with fewer than 10 hours of wear time were excluded, and only participants with at least one day of valid accelerometer data were included in the analysis.[14]

Total step count was calculated as the sum of daily steps and determining the median number of valid days per participant.Step frequency (steps per minute) is a gait parameter that represents the cumulative number of steps within a one-minute interval.Alternative terms for step frequency include step rate, pace, stride frequency, stride rate, and walking rhythm.[14] In this study, we estimated step frequency using three distinct indicators.First, we determined walking bout step frequency by identifying sustained walking bouts—continuous periods of at least 2 minutes with a step rate of 60 steps per minute or higher (indicative of brisk walking)—on valid days.Using these bouts, we calculated the average bout step frequency (steps per minute).Furthermore, we calculated the highest 30-minute step frequency (peak 30) and the highest 1-minute step frequency (peak 1).[12,14] To compute the peak 30-minute step frequency, we selected the 30 highest step frequency values each day, averaged these values daily, and then computed an overall average across all days.To determine the peak 1-minute step frequency, we identified the highest 1-minute step frequency each day and calculated the average across all days.Step frequency were categorized into quartiles based on the distribution within the study population.

Other Covariates

To control for potential confounders, the study included covariates for gender (male, female), age (40–60 and 60–80 years), education level (high school graduate or less versus high school graduate or more), marital status (married versus unmarried), and race (Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, Other/multiracial).Body mass index (BMI) was computed by dividing weight in kilograms by height in meters squared (kg/m^2) and categorized into three groups: <25, 25 to <30, and ≥30.The poverty-to-income ratio was determined by dividing household income by the poverty threshold for the corresponding survey year and categorized as <1.3, 1.3 to <3.5, or ≥3.5.Smoking status was classified as current, former, or never smoker.Drinking status was classified as drinker or non-drinker.Comorbidities were defined based on responses to an interviewer-administered NHANES questionnaire, which asked, "Has a doctor or other health professional ever told you that you have…?".The study considered comorbidities including congestive heart failure, coronary heart disease, and diabetes.For improved reproducibility, we have provided detailed variable definitions, coding schemes, and covariate information in Supplementary material (NHANES Variable Information).

Statistical Analysis

In accordance with National Center for Health Statistics guidelines, survey weights were applied to adjust for the complex sampling design of NHANES in all analyses. Participants were stratified into subgroups based on valid step counts to establish baseline characteristics.Weighted sample sizes and percentages were computed for demographic variables (gender, age, education, race, marital status), anthropometric indices (BMI), and comorbidities (congestive heart failure, coronary heart disease, diabetes).Population characteristics were summarized as absolute frequencies and proportions. Between-group differences were assessed via one-way ANOVA or χ^2-tests, as appropriate.Weighted logistic regression models estimated odds ratios (ORs) and 95% confidence intervals (CIs) for associations between daily step counts, step frequency, and COPD risk.The final model adjusted for age, sex, education, race/ethnicity, marital status, BMI, smoking status, alcohol use, and comorbidities.Linear trends across ordinal categories were assessed using ordinal values in separate models.

To assess the nonlinear relationship between daily step count and COPD risk, we used restricted cubic splines with four knots to model the dose-response association.Furthermore, natural splines were employed for data modeling, with knots positioned at the 25th, 50th, and 75th percentiles. This approach divided the range into four intervals, each represented by a basis function.The model is specified as follows:

$$Y = \beta_0 + \sum_{k=1}^{4} \beta_k \cdot h_k(X)$$

In this equation, $h_k(X)$ represents the natural spline basis function for the independent variable X, βk is the regression coefficient, β0 is the intercept term, and K is the number of basis functions.The analysis accounted for relevant covariates.This methodology was also applied to subgroup analyses by gender, age, and body mass index.The study assessed the predictive validity of daily step count and walking intensity for COPD using the area under the receiver operating characteristic curve (AUC), adjusted with inverse probability weighting, and estimated the 95% confidence interval using the bootstrap method.

We conducted several sensitivity analyses to assess the study's robustness: (I) We examined the association between step count and COPD risk using multiple step count classification criteria. (II) We investigated the association among step count, step frequency, and COPD risk using raw data collected from 2005 to 2006. (III) We validated the relationship among step count, walking intensity, and COPD risk using propensity score matching. We employed 1:1 nearest neighbor matching without replacement using a caliper width of 0.05 of the standard deviation of the logit of the propensity score. The variables used to construct the propensity score included age, sex, race/ethnicity, body mass index, smoking status, education level, household income, and comorbidities (eg, diabetes, hypertension).We used R (Version 4.2.0, available at http://www.r-project.org) for statistical analysis, considering P<0.05 as statistically significant.

Results

Table 1 presents the baseline characteristics of study participants categorized by daily step count: <4000, 4000–7999, and ≥8000.The study comprised 3690 participants, representing a weighted population of 26,783,497.The majority of

Table 1 Characteristics of the Analytical Sample (n=3690)

Characteristic	**Steps/d, No. (%)[a]**				
	Total (N=3690,100%)	**<4000 (n=2815,72%)**	**4000-7999 (n =669,23%)**	**≥8000 (n =206,5.4%)**	***P* value**
Age					<0.001
40-60 years	1952 (67%)	1406 (64%)	477 (83%)	69 (42%)	
60-80 years	1738 (33%)	1409 (36%)	192 (17%)	137 (58%)	
Sex					0.017
Female	1884 (54%)	1469 (55%)	313 (49%)	102 (55%)	
Male	1806 (46%)	1346 (45%)	356 (51%)	104 (45%)	
Race					0.010
Mexican American	746 (5.6%)	584 (6.0%)	123 (4.7%)	39 (4.6%)	
Non-Hispanic Black	780 (10.0%)	650 (11%)	107 (6.7%)	23 (4.9%)	
Non-Hispanic White	1955 (77%)	1427 (76%)	398 (82%)	130 (85%)	
Other Hispanic	96 (3.1%)	74 (3.2%)	17 (2.9%)	5 (2.2%)	
Other/multiracial	113 (3.9%)	80 (3.9%)	24 (3.9%)	9 (3.7%)	
Education					<0.001
<High school	1864 (39%)	1557 (43%)	242 (29%)	65 (28%)	
≥High school	1826 (61%)	1258 (57%)	427 (71%)	141 (72%)	
BMI					<0.001
<25	847 (25%)	571 (21%)	201 (34%)	75 (44%)	
25 to <30	1393 (37%)	1061 (36%)	241 (37%)	91 (40%)	
30 or greater	1450 (38%)	1183 (43%)	227 (28%)	40 (16%)	

(*Continued*)

Table 1 (Continued).

Characteristic	Steps/d, No. (%)[a]				
	Total (N=3690,100%)	**<4000 (n=2815,72%)**	**4000-7999 (n =669,23%)**	**≥8000 (n =206,5.4%)**	***P* value**
Smoking					0.3
Never smoker	2068 (57%)	1566 (57%)	400 (60%)	102 (50%)	
Former smoker	1493 (40%)	1146 (40%)	248 (37%)	99 (47%)	
Current smoker	129 (3.1%)	103 (3.1%)	21 (2.9%)	5 (3.8%)	
Alcohol					<0.001
Non-drinker	2983 (77%)	2342 (79%)	504 (71%)	137 (64%)	
Drinker	707 (23%)	473 (21%)	165 (29%)	69 (36%)	
Marital status					0.001
Never married	1167 (27%)	953 (28%)	162 (20%)	52 (27%)	
Married	2523 (73%)	1862 (72%)	507 (80%)	154 (73%)	
PIR					<0.001
<1.3	857 (13%)	784 (16%)	65 (5.9%)	8 (3.0%)	
1.3 to <3.5	1384 (34%)	1222 (41%)	149 (19%)	13 (9.2%)	
≥3.5	1449 (53%)	809 (43%)	455 (75%)	185 (88%)	
CHD					0.2
Yes	253 (5.6%)	192 (5.7%)	41 (4.7%)	20 (8.9%)	
No	3437 (94%)	2623 (94%)	628 (95%)	186 (91%)	
CHF					0.004
Yes	169 (3.3%)	148 (3.9%)	16 (1.3%)	5 (2.6%)	
No	3521 (97%)	2667 (96%)	653 (99%)	201 (97%)	
DM					<0.001
Yes	606 (12%)	512 (14%)	62 (5.9%)	32 (11%)	
No	3084 (88%)	2303 (86%)	607 (94%)	174 (89%)	
COPD					<0.001
Yes	298 (8.1%)	254 (9.6%)	36 (4.7%)	8 (3.1%)	
No	3392 (92%)	2561 (90%)	633 (95%)	198 (97%)	

Note: [a]Weighted to be nationally representative.
Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared);PIR, Family poverty income ratio; CHD,coronary heart disease;CHF,congestive heart failure;DM,Diabetes;COPD, chronic obstructive pulmonary disease.

participants (72%) took fewer than 4000 steps/day, while 23% took 4000–7999 steps/day, and 5.4% took ≥8000 steps/day.Among participants taking ≥8000 steps/day, non-Hispanic whites comprised the highest proportion (85%, P=0.010), and the proportion with a BMI <25 kg/m² was significantly greater (44%, P<0.001).Additionally, 72% of this group had completed at least high school (P<0.001), and 88% had a PIR ≥3.5 (P<0.001).Participants with higher daily step counts had a greater proportion of alcohol consumers (36%, P<0.001), whereas smoking status showed no significant association

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(P=0.3).Daily step count was inversely associated with COPD prevalence.Among those taking ≥8000 steps/day, COPD prevalence was 3.1%, significantly lower than the 9.6% observed in the <4000 steps/day group (P<0.001).Diabetes prevalence was also lower in the high step count group (P<0.001). However, the associations between step count and CHD (P=0.2) were not statistically significant.Although the association between step count and CHF was statistically significant (p=0.004), its clinical relevance remains uncertain.

Individuals who walked 4000–7999 steps per day had a 37% lower risk of COPD (Adjusted Model 4: OR 0.63, 95% CI 0.40–1.00) compared to those taking fewer than 4000 steps per day.Participants walking more than 8000 steps per day had a 63% lower risk of COPD (OR 0.37, 95% CI 0.15–0.91).Trend analysis indicated a significant inverse correlation between daily step count and COPD risk (P < 0.001).Greater step frequency, measured by step cadence and peak step speed (over 30 minutes and 1 minute), was significantly associated with a reduced COPD risk. Compared to the lowest cadence group, participants in the highest step cadence category (92.3–153.4 steps/minute) had a 70% lower risk of COPD (OR 0.30, 95% CI 0.19–0.47).Participants in the highest peak 30-minute step speed category (69.8–128.2 steps/minute) had a 67% lower risk of COPD (OR 0.33, 95% CI 0.19–0.56).Trend analysis further demonstrated an inverse correlation between step frequency and COPD risk (P < 0.001) (Table 2).

Table 2 The Association of Daily Step Count and Step Intensity with the Risk of COPD Among US Adults Aged at Least 40 years

Characteristic	Event N	Weighted N(%)	Odds Ratio (95% CI)			
			Model 1	Model 2	Model 3	Model 4
Daily Step Count (Steps/d)						
[0,3999]	254/2815	1,842,946 (10%)	–	–	–	–
[4000,7999]	36/669	286,939 (5%)	0.46(0.31, 0.69)	0.54(0.35, 0.83)	0.63(0.41, 0.97)	0.63(0.40, 1.00)
[8000,)	8/206	45,953 (3%)	0.31(0.12, 0.76)	0.30(0.12, 0.74)	0.37(0.15, 0.86)	0.37(0.15, 0.91)
P for trend	–	–	<0.001	<0.001	<0.001	<0.001
Bout cadence (steps per minute)						
No bouts	13/126	64,905 (10%)	0.76(0.32, 1.76)	0.53(0.21, 1.36)	0.47(0.18, 1.26)	0.39(0.12, 1.24)
[60.8,78.5]	101/891	755,970 (13%)	–	–	–	–
[78.5,84.5]	68/892	548,439 (9%)	0.65(0.45, 0.94)	0.65(0.45, 0.95)	0.64(0.42, 0.98)	0.64(0.41, 1.01)
[84.36,92.33]	75/890	522,881 (8%)	0.64(0.43, 0.94)	0.63(0.43, 0.93)	0.64(0.43, 0.95)	0.62(0.42, 0.92)
[92.32,153.37]	41/891	283,643 (4%)	0.28(0.19, 0.41)	0.26(0.18, 0.39)	0.31(0.20, 0.47)	0.30(0.19, 0.47)
P for trend	–	–	<0.005	<0.001	<0.001	<0.001
Peak 30 cadence (steps per minute)						
[0,46.67]	114/927	727,390 (13%)	–	–	–	–
[46.72,58.73]	85/918	589,520 (10%)	0.71(0.50, 1.00)	0.78(0.54, 1.12)	0.83(0.57, 1.23)	0.83(0.57, 1.23)
[58.75,69.8]	67/922	587,842 (9%)	0.60(0.42, 0.85)	0.73(0.50, 1.06)	0.86(0.56, 1.33)	0.86(0.56, 1.33)
[69.82,128.23]	32/923	271,085 (3%)	0.22(0.13, 0.35)	0.26(0.16, 0.42)	0.33(0.19, 0.56)	0.33(0.19, 0.56)
P for trend	–	–	<0.05	<0.001	<0.001	<0.001

(*Continued*)

Table 2 (Continued).

Characteristic	Event N	Weighted N(%)	Odds Ratio (95% CI)			
			Model 1	Model 2	Model 3	Model 4
Peak 1 cadence (steps per minute)						
[0,72]	104/926	631,035 (11%)	–	–	–	–
[72.125,83.125]	83/920	666,003 (11%)	0.98(0.63, 1.53)	1.11(0.72, 1.71)	1.11(0.70, 1.75)	1.13(0.70, 1.84)
[83.25,92]	64/922	456,976 (7%)	0.56(0.39, 0.79)	0.67(0.46, 0.96)	0.71(0.48, 1.06)	0.74(0.49, 1.13)
[92.125,144]	47/922	421,824 (9%)	0.42(0.24, 0.73)	0.51(0.28, 0.92)	0.61(0.32, 1.16)	0.62(0.31, 1.23)
P for trend	–	–	0.06	<0.001	<0.001	0.047

Notes: Model 1: adjusted for none. Model 2: adjusts for sex, age, race, BMI. Model 3: adjusts for sex, age, race, BMI, Education, Smoking,Alcohol,Marital status,PIR. Model 4: adjusts for sex, age, race, BMI, Education, Smoking,Alcohol,Marital status,PIR, CHD, CHF, DM.
Abbreviations: CHF, congestive heart failure; CHD, coronary heart disease;DM, Diabetes.

This study examines the combined effects of daily step count and step frequency on the risk of developing chronic obstructive pulmonary disease (COPD).Using detailed data on step count and step frequency from study participants, we identified several notable trends: Among participants with higher step cadence—regardless of whether measured as bout cadence, 30-minute cadence, or 1-minute cadence—those with higher daily step counts had a significantly lower risk of COPD. In contrast, among individuals with low step cadence across all cadence measures, increasing step counts did not confer a meaningful reduction in COPD risk; the odds ratios were close to 1 and all confidence intervals included the null value. These findings indicate that the protective effect of daily step count may be restricted to individuals who also maintain a higher walking cadence, suggesting a joint role of step volume and intensity in COPD prevention. (Table 3). eFigure 1 illustrates the prevalence of COPD as a function of combined step count and step frequency.

Table 3 Joint Association of Daily Step Count and Step Intensity with the Risk of COPD Among US Adults Aged at Least 40 years

Step Intensity	Daily Step Count	Event N	Weighted N(%)	Odds Ratio (95% CI)			
				Model 1	Model 2	Model 3	Model 4
Bout cadence (Steps/d)							
[60.8,84.5]	[0,3999]	154/1568	1,170,240 (11%)	–	–	–	–
	[4000,)	15/215	134,169 (8%)	0.67(0.31, 1.43)	0.82(0.37, 1.83)	0.90(0.38, 2.11)	0.90(0.36, 2.26)
[84.6,153.37]	[0,3999]	87/1121	607,801 (8%)	0.69(0.48, 0.99)	0.67(0.47, 0.96)	0.70(0.49, 0.99)	0.68(0.48, 0.96)
	[4000,)	29/660	198,723 (3%)	0.29(0.18, 0.46)	0.31(0.19, 0.50)	0.37(0.22, 0.62)	0.36(0.21, 0.63)
Peak 30 cadence (steps per minute)							
[0,58.73]	[0,3999]	192/1767	1,279,454 (12%)	–	–	–	–
	[4000,)	7/78	37,457 (6%)	0.47(0.15, 1.46)	0.47(0.14, 1.52)	0.55(0.16, 1.86)	0.52(0.14, 1.89)
[58.75,128.23]	[0,3999]	62/1048	563,492 (7%)	0.54(0.38, 0.78)	0.63(0.44, 0.91)	0.72(0.48, 1.08)	0.71(0.46, 1.10)
	[4000,)	37/797	295,435 (4%)	0.33(0.22, 0.50)	0.39(0.25, 0.62)	0.49(0.30, 0.80)	0.49(0.29, 0.82)

(*Continued*)

Table 3 (Continued).

Step Intensity	Daily Step Count	Event N	Weighted N(%)	Odds Ratio (95% CI)			
				Model 1	Model 2	Model 3	Model 4
Peak 1 cadence (steps per minute)							
[0,83]	[0,3999]	176/1631	1,218,296 (12%)	–	–	–	–
	[4000,)	11/215	78,742 (5%)	0.36(0.13, 1.00)	0.38(0.14, 1.07)	0.45(0.15, 1.30)	0.44(0.14, 1.35)
[83.25,144]	[0,3999]	78/1184	624,650 (7%)	0.52(0.37, 0.72)	0.57(0.40, 0.80)	0.62(0.43, 0.89)	0.62(0.42, 0.92)
	[4000,)	33/660	254,150 (4%)	0.32(0.21, 0.49)	0.37(0.23, 0.60)	0.46(0.27, 0.77)	0.46(0.26, 0.81)

Notes: Model 1: adjusted for none. Model 2: adjusts for sex, age, race, BMI. Model 3: adjusts for sex, age, race, BMI, Education, Smoking,Alcohol,Marital status,PIR. Model 4: adjusts for sex, age, race, BMI, Education, Smoking,Alcohol,Marital status,PIR, CHD, CHF, DM.
Abbreviations: CHF, congestive heart failure; CHD, coronary heart disease;DM, Diabetes.

We employed restricted cubic splines to illustrate the nonlinear relationship between daily step count and COPD prevalence among patients.After adjusting for confounding variables, we observed a significant nonlinear association between step count and COPD prevalence (overall and nonlinearity, $p < 0.01$; see Figure 1).The natural spline analysis indicated that step count significantly influenced COPD prevalence in the first two intervals (OR = 0.53 and 0.12, respectively; both $p < 0.05$).In contrast, in the latter two intervals, step count did not significantly affect COPD prevalence, particularly in the fourth interval (OR = 0.46; 95% CI, 0.00–489; p = 0.8; see eTable 1). eFigure 2 illustrates the dose-response relationship among subgroups defined by gender, age, and BMI.Additionally, receiver operating characteristic (ROC) curves were used to evaluate the predictive performance of step count and step frequency for COPD risk (see Figure 2 and eTable 2).The results indicated that both step count and step frequency possess predictive value for COPD risk.

In the sensitivity analysis, we re-categorized step counts and analyzed missing data without imputation.The results were consistent with those of the primary analysis (see eTables 3, 4 and eFigure 3).After adjusting for covariates via propensity score matching, we observed that COPD patients exhibited lower daily step counts and step frequencies—including peak 30-minute and 1-minute measures—than non-COPD patients (see eTable 5).

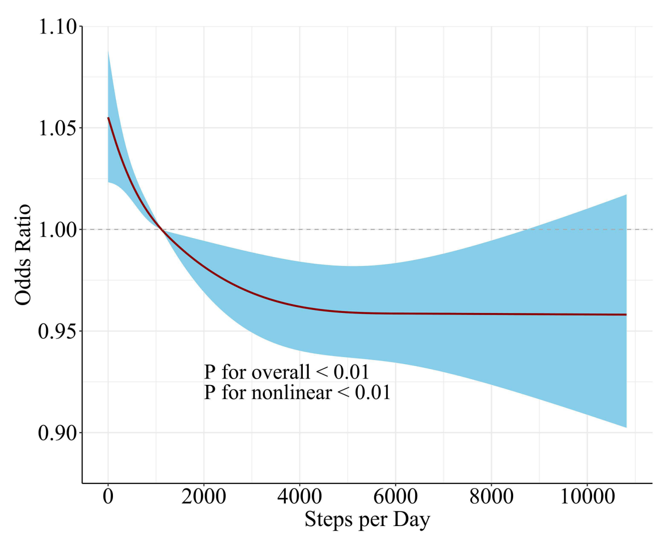

Figure 1 Dose-response associations between step count and the risk of COPD. A restricted cubic spline regression model with four knots (at the 5th, 35th, 65th, and 95th percentiles) was used to estimate the dose-response association of Step per Day and the risk of COPD. The solid line and blue shading represent odds ratios and 95% CIs, respectively. Models were adjusted for sex, age, race, BMI, Education, Smoking, Alcohol,Marital status,PIR, CHD, CHF, DM. P-values for nonlinear associations are shown in the figure.

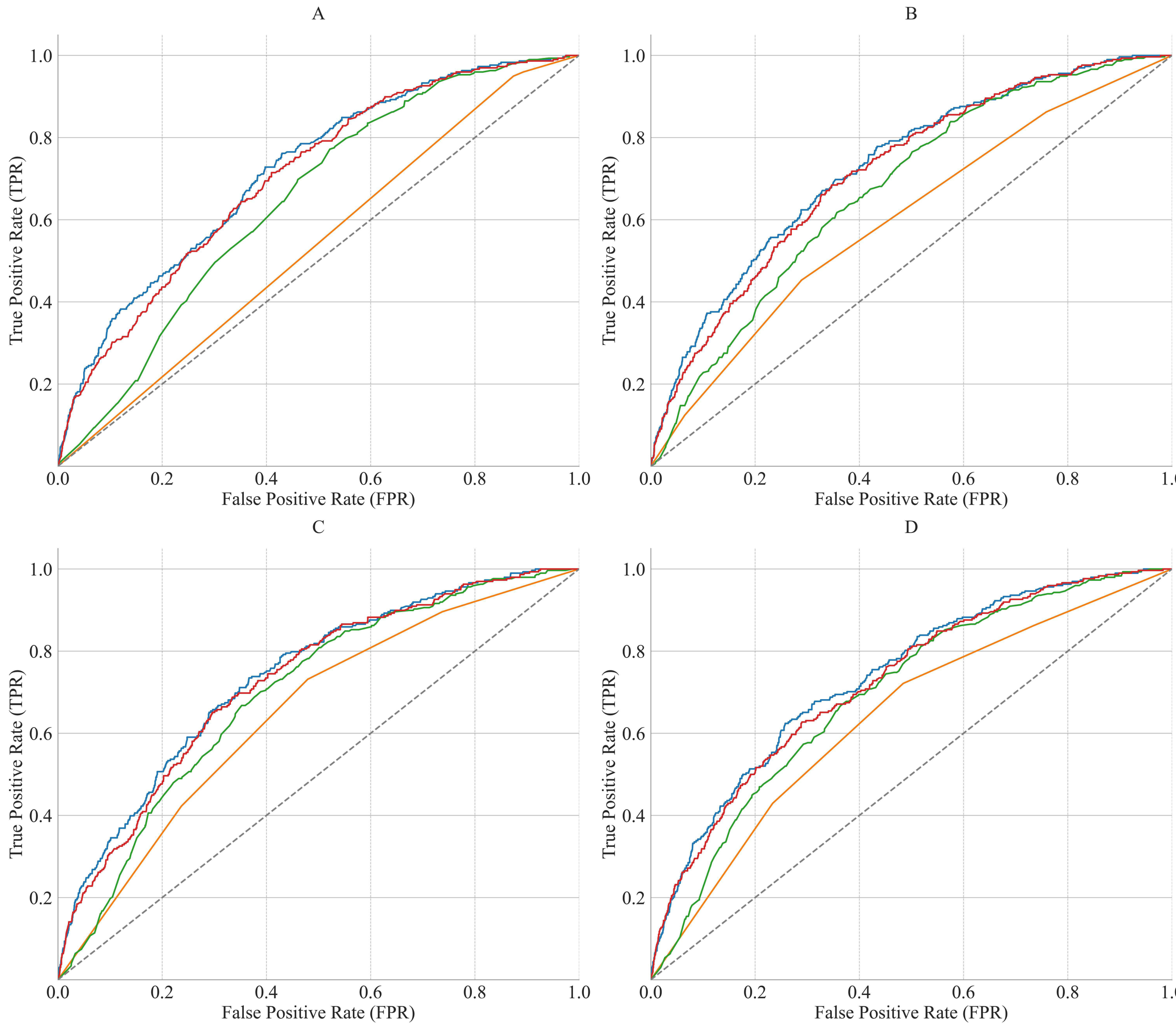

Figure 2 ROC curve analysis. (**A**) Step count per day and COPD; (**B**) Bout cadence and COPD; (**C**) Peak 30 cadence and COPD; (**D**) Peak 1 cadence and COPD. Model 1: adjusted for none. Model 2: adjusts for sex, age, race, BMI. Model 3: adjusts for sex, age, race, BMI, Education, Smoking,Alcohol,Marital status,PIR. Model 4: adjusts for sex, age, race, BMI, Education, Smoking,Alcohol,Marital status,PIR, CHD, CHF, DM.

Discussion

This cohort study examined the association between daily step count, step frequency, and COPD risk in a representative US sample. The findings suggest that a higher step count and faster walking pace are linked to a lower COPD risk.As a simple and easily measurable indicator of physical activity, daily step count could serve as an effective public health strategy for reducing COPD risk.This study supports integrating step-based guidelines into future physical activity (PA) recommendations, allowing high-risk individuals to monitor their PA levels using personalized step count goals that may contribute to lowering the risk of COPD.

Studies have shown an inverse association between daily step count and mortality risk in patients with COPD.An increase of 1845 steps per day is associated with a significantly lower mortality risk (HR: 0.49, 95% CI: 0.35–0.69, $P < 0.001$).[15] Target step counts may help identify sedentary behavior in patients with COPD and promote increased physical activity in those with low baseline step counts.[16,17] Patients with COPD who have lower daily step counts are at a significantly higher risk of acute exacerbations and COPD-related hospitalizations.[18] These studies highlight step count as a key quantitative measure in COPD rehabilitation, diagnosis, and treatment, whereas our study focuses on the role of walking in COPD prevention.Additionally,

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our study investigated the association between step frequency and COPD risk.Patients with COPD have a significantly lower average step frequency than the general population, which is strongly associated with disease severity and the risk of severe acute exacerbations.[19] Patients with COPD exhibit gait abnormalities, including reduced step frequency, increased step frequency variability, and decreased step width variability, which may elevate their fall risk.[20] Our study found that a higher step frequency was associated with a lower risk of COPD, suggesting that both step count and step frequency should be incorporated into daily walking-based exercise.Monitoring and adjusting step frequency or pace can help tailor exercise prescriptions for patients with COPD, enabling a safe and gradual increase in physical activity intensity to support prevention and rehabilitation.

Our findings have important implications for clinical research, medical practice, and public health.These findings suggest that promoting regular walking may be associated with a lower risk of COPD and could potentially inform future intervention strategies.This study introduces new perspectives on COPD rehabilitation and provides clinical evidence for developing personalized step-count-based rehabilitation plans.Expanding on prior research, this study provides additional epidemiological evidence supporting the potential role of walking as a non-pharmacological approach for COPD prevention.This approach may reduce COPD-related morbidity and mortality, lower healthcare resource utilization, and ease the financial burden on patients, ultimately decreasing the socioeconomic costs of COPD.The study's findings are also relevant for public health policy development.These findings support walking-based physical activity guidelines, providing a scientific foundation and practical reference for public health initiatives.Future research should determine the optimal intensity and frequency of walking interventions across populations to maximize their benefits for COPD prevention and management.

A key strength of this study is the use of nationally representative NHANES data, allowing for population-level generalizability.The study used accelerometer data to objectively measure daily step counts over one week, minimizing exposure misclassification bias from self-reports.Additionally, the analysis accounted for multiple potential confounders. However, this study has certain limitations.As daily step counts were measured for only one week at baseline, the study does not account for long-term changes in walking behavior and their impact on COPD risk.As this is a cross-sectional study, causal inferences cannot be drawn, and the association between step count and COPD risk requires further validation.Pulmonary function tests are crucial for COPD diagnosis and assessment, but these data were unavailable in this study.COPD diagnosis was based on questionnaire data, which may introduce misclassification bias due to the absence of spirometry-based confirmation. This limitation should be considered when interpreting the results.

Conclusion

This study, based on a representative sample of US adults, identified an association between daily step count, step frequency and COPD risk.Increased daily step counts and higher step frequency were linked to a reduced COPD risk. These findings suggest that higher levels of step-based physical activity are associated with a lower risk of COPD, highlighting the potential value of promoting physical activity in populations at risk.Higher daily step counts and greater step frequency are associated with a lower risk of COPD, suggesting a potential role in public health strategies.However, due to the cross-sectional nature of the study, reverse causality cannot be ruled out; individuals with undiagnosed or early-stage COPD may engage in less physical activity due to subclinical symptoms. Future prospective studies with spirometry-confirmed COPD diagnoses are essential to validate these findings and explore causal relationships. In addition, future research should investigate how environmental and occupational exposures, such as air pollution or workplace hazards, may modify the protective association between physical activity and COPD risk.

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Disclosure

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